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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Steven C. Avanzino

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EXAMINER

DAHIMENE, MAHMOUD

ART UNIT

PAPER NUMBER

1765

DATE MAILED: 06/05/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/726,992

Applicant(s)

AVANZINO, STEVEN C.

Examiner

Mahmoud Dahimene

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 1 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 29 March 2006.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-20 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-20 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|---|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| Paper No(s)/Mail Date. _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1,2,3,5,7,8,9,10,11,14 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638)

Uozumi discloses a method for etching a copper film or structure, which reads on "the copper containing material comprising at least 10% by weight copper", the method comprises the steps of forming a copper oxide layer by contacting the copper surface with an aqueous hydrogen peroxide containing solution, and then removing the copper oxide from the copper film using an acid containing solution (see column 4 line 7-14), the acid may be organic (column 5, line 15). The benefit of controlling the pH of the oxidizing solution is also addressed in the reference (figure 6). Uozumi clearly teaches two-step copper film etching is conventionally used in the art, the first step modifies a thin layer on the copper surface, the second step removes the modified layer on the copper surface.

A difference is noted between the applicant's claims and the reference of Uozumi. Uozumi's first solution comprises ammonia, hydrogen peroxide and water,

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whereas the applicant's first solution comprises a first organic acid, a peroxide compound and water.

Kondo et al. teach an abrasive free polishing method wherein copper is removed using a polishing solution comprising an oxidizer and a substance that renders the oxidized copper water soluble, in particular, a mixture of citric acid and aqueous hydrogen peroxide is cited as being a typical example of a polishing solution (column 5, line 22). The citric acid-based solution is shown (figure 9) to have a pH within the range of 2 to 6. Kondo cites "in the domain of corrosion (pH between less than 7 and oxidation reduction potential greater than 0.2 (column 6, lines 44-46)), copper is rendered water soluble and ionized at a much faster rate than in the domain of passivation (column 5, line 29). Figure 9 also shows that for a minimum oxidation-reduction potential of less than 0.2 the pH of the solution is less than 6, also figure 26 illustrates pH less than 6 is desirable for faster corrosion rate.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the process of Uozumi to replace the first solution with the solution of Kondo to provide faster etch rate and a wider range of stability for the etch process, as illustrated by a progressive variation of etch rate versus pH (see Kondo, figure 26) , and therefor, better control of the process. The sharp rise in etch rate versus pH for the ammonia-based solution in figure 6 of Uozumi is not desirable for process control. One of ordinary skill in the art would have been motivated to replace the first solution of Uozumi with the solution of Kondo in order to obtain better control of the etch as the pH of the solution may vary with time and use.

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Uozumi also differs from the claimed invention by using a second solution comprising an acid (which could be organic), instead of the applicant's second solution which comprises a organic acid (from list in claim 2) and water,

Kondo's teachings also include organic acids are substances that render copper and copper oxide water soluble (column 6, line33, and column 12, line29).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the second solution of Uozumi to use an organic acid to render any byproduct of the first solution water soluble, the second step not comprising a peroxide compound will stabilize the surface from further oxidation, because the reference of Kondo et al. illustrates how organic acids are used in controlled scratch free polishing of copper resulting in a smooth surface.

One of ordinary skill in the art would have been motivated to combine the teachings for a two-step copper etch method and the advantages of organic acids in order to obtain an abrasive free controllable copper etch method that provides scratch free smooth surfaces.

As to claims 3 and 5, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method cited above is silent about the proportions or range of the components in solutions 1 and 2 as described by applicant's claims 3 and 5.

Kondo et al. describe a polishing solution with 30% aqueous H_2O_2 , and 0.03 wt % citric acid (column 12, lines 32 and 48) which is included in applicant's claimed ranges. Overlapping ranges are held obvious.

As to claim 7, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method, cited above, fails to disclose a range for the pH in the first solution specifically consisting of a peroxide compound, an organic acid and water, as the applicant's claim 7.

Kondo et al. disclose the corrosion rate of a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide (figure 26, and column 5, line 22). Figure 26 shows that for the citric acid based solution, corrosion rate (etching rate) (column 5, line 17)) is higher when the pH of the solution is in the range of 1 to 6. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the method of Uozumi's, as described above, where solutions 1 and 2 have a pH in the range where oxidation is maximized for solution 1 (pH is about 3 or less for highest corrosion rate according to figure 26 of Kondo), and copper oxide removal is optimized for solution 2 (corrosion rate does not need to be high for the second solution, so a pH of less than 7 is acceptable according to figure 26 of Kondo). Overlapping ranges are held obvious.

As to claim 8, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method, cited above, is silent about an operating temperature range for solutions 1 and 2 as described in applicant's claim 8.

Kondo et al. disclose a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide. For the cited example the temperature of the polishing solution was room temperature (column 12, line 37), which is included in the applicant's temperature range. Applicants have not shown anything critical with respect to the

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temperature of solutions 1 and 2. In the absence of unexpected results, it would appear that any temperature near standard room temperature would have produced comparable results.

As to claim 9, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's reference fails to specify oxide as a passivation layer.

Kondo et al. discloses an oxide is formed when copper is contacted with a solution where the pH and oxidation-reduction potential are in the domain of corrosion of said metal (column 21, line 5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify Uozumi, as described above, to include Cu oxide as the passivation because, as taught by Kondo oxide is formed when the pH of the solution and oxidation-reduction potential are in the domain of corrosion of copper.

As to claim 10, Uozumi discloses a method for etching a copper film or structure, which reads on the claimed "the copper containing material comprising at least 25% by weight copper". The limitations [of contacting the copper structure with a first solution to convert at least a portion of the copper structure to a passivating film, the first solution comprising a peroxide compound, a first organic acid, and water and having a PH from about 2 to about 6., contacting the passivating film with a second solution to remove the passivating film, the second solution comprising a second organic acid and water] have been addressed above. As to the limitation citing "the second solution having a lower PH and a higher temperature than the PH and temperature of the first solution" see the

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rejections in reference of claims 7 and 8. As to rinsing the wafer, it would have been obvious to one of ordinary skill in the art at the time the invention was made to rinse the wafer after the second step in order to remove any residues and byproducts from the second step.

In addition, and relative to applicant's claim 10, Uozumi discloses that the copper etching rate depends on the solution pH (figure 6). Uozumi also discloses that too high corrosion (oxidation) in the first step results in rougher surface (column 2, line 60).

Kondo et al. teach that, for a citric acid-based solution, the corrosion rate increases with decreasing pH (figure 26).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify Uozumi's method, as described above, to increase the pH of the first solution relative to the second in order to control the corrosion (oxidation) during the first step in order to obtain a smoother surface (the second solution does not rely corrosion to remove the oxide layer).

As for the temperature Uozumi teaches that during the oxidation step, high temperature results in rougher surface as the rate of oxidation increases in the first solution (column 2, line 62).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to use a lower temperature for the first solution, relative to the second solution, to control corrosion in the first step in order to obtain a smoother surface.

As to claim 11, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method, cited above, is silent about specific proportions of peroxide compound, organic acid, water, surfactant and pH adjuster.

Kondo et al. describe a polishing solution with 30% aqueous H₂O₂, and 0.03 wt % citric acid (column 12, lines 32 and 48) which is in the range of the applicant's claim 11 for the peroxide compound, organic acid, water.

Kondo fails to teach specific proportions for surfactant and pH adjuster but they do illustrate the benefits of adjusting the pH (column 5, line 3) as well as the optional use of surfactants (column 9, line 4).

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper proportions of pH adjuster and surfactant to effectively control the solution properties in order to accomplish the desired etch results (smoothness), because it has been held that there is no invention where the difference in proportions is not critical and was ascertained by routine experimentation because the determination of workable ranges is not considered inventive.

As to claim 14, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method, cited above, fails to disclose a specific process time range for solutions 1 and 2 as applicant's claim 14 describes.

Kondo et al. disclose a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide. The time cited for a specific example was 400 seconds, which is in the range specified in applicant's claim 14. In addition, oxidation and etching times depends on the initial thickness and the exact specification for the desired results.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to specify a time for oxidation based on desired results including thickness to be removed and smoothness (as disclosed by Kondo et al.), and a time for oxide removal based on the desired quality of the final etched surface. One of ordinary skill in the art would have been motivated to determine, through routine experimentation, the process time for each step depending on the desired results.

As to claim 16, a difference is noted between the teachings of Uozumi and applicant's claimed invention. Uozumi's method cited above fails disclose a specific R_{tm} . Kondo et al. describe a polishing solution with 30% aqueous H_2O_2 , and 0.03 wt % citric acid (column 12, lines 32 and 48). Kondo also fails to specify a surface R_{tm} . However Kondo et al. discuss critical parameters for obtaining a smooth surface.

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper parameters such as pH, temperature and oxidation time, to experimentally select the degree of smoothness as specified by other requirements.

Claim Rejections - 35 USC § 103

3. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638) and further in view of Miller (US 6719920).

Uozumi's method cited above fails to disclose specific proportions of organic acid, water, biocide and pH adjuster.

Kondo describes a polishing solution with 30% aqueous H₂O₂, and 0.03 wt % citric acid (column 12, lines 32 and 48) which is in the in the range of the applicant's claim 12, for organic acid and water. Kondo fails to teach specific proportions for biocide and pH adjuster but do illustrate the benefits of adjusting the pH (column 5, line 3).

Miller discloses that the addition of biocides (column 4, line 15) may help eliminate, from a solution, organisms that could yield undesirable results, but does not specify the proportions to be used in the above solution.

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper proportions of pH adjuster and biocide to effectively control the solution properties in order to accomplish the desired etch results (smoothness) and an organism free solution, because it has been held that there is no invention where the difference in proportions is not critical and was ascertained by routine experimentation because the determination of workable ranges is not considered inventive.

Claim Rejections - 35 USC § 103

4. Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638) and further in view of Shimazu et al. (US 6547843).

Uozumi's method has been described above. A difference is noted between the applicant's claim and the references of Uozumi and Kondo et al. both Uozumi and Kondo et al. references fail to include a second acid in the second solution.

Shimazu et al. disclose a copper polishing solution including one or more organic acids (e.g. acetic acid, citric acid, etc.) (column 5, line 21).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the process of Uozumi, as described above, to include at least two organic acids to obtain a solution where the combined action of the acids yields a better copper etch by adjusting selectivity as different materials are used as dielectric isolation, also different acids have different reactions with different copper compounds. One of ordinary skill in the art would have been motivated to combine the teachings for a two-step method and the advantages of combining organic acids in order to obtain a smoother surface and control selectivity.

Claim Rejections - 35 USC § 103

5. Claim 17-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638), and further in view of Singh et al. (US 6594024).

The references of Uozumi and Kondo et al. have been discussed above. A difference is noted between the applicant's claims and the reference of Uozumi. and Kondo et al. wherein the disclosures do not include a monitoring or endpoint method.

Singh et al. teach a method for monitoring a CMP polishing process using scatterometry, the disclosed method includes comparing the signature (column 14, line 58) associated with removing a layer to a signature library (column 14, line 61) for terminating a process when the desired depth is attained as in applicant's claim 17. Singh's method involves directing a beam of light at the processed layer and collecting a light reflected from the processed layer (column 3, line 50) and transforming the signal into a signature as in applicant's claim 18. Singh's method also includes a closed loop feedback control system (column 14, line 63), and it is capable of endpoint functions (column 2, line 47) including layer profiles as in applicant's claims 19 and 20.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to incorporate Singh's control system into the modified teachings of Uozumi's to allow for etch process control. Endpoint detection and control systems are commonly used in semiconductor etch, CMP, and deposition technologies.

Claim Rejections - 35 USC § 103

6. Claims 4,6 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) as applied to claim 1,2,3,5,7,8,9,10,11,14 and 16 above, in view of Kondo et al. and further in view of APA (admitted prior art).

With respect to claims 4, 6 and 15, the modified teachings of Kondo are silent regarding the presence of surfactants, however, applicant admitted prior art specifically cite that surfactants (US 6596638), are known in the art (Page 8, line 9).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to further modify the method of Uozumi to include surfactants in the solutions, because surfactants enhance surface reaction for etching and oxide removal. It would have been obvious to one skilled in the art to add a surfactant to the solutions to obtain a smoother surface.

Response to Arguments/Amendments

1. Applicant's arguments filed on 03/29/2006 have been fully considered but they are not persuasive. A discussion of the rejection follows.

As to the applicant's argument that there is no motivation to make the modifications of replacing the first and second solution of Uozumi as described above, the examiner maintains, that better process control, as suggested by Kondo and described above, is a good motivation for modifying the method of Uozumi.

As to the applicant's argument citing "It would NOT have been obvious to replace the ammonia-hydrogen peroxide solution of Uozumi with the citric acid-hydrogen peroxide polishing solution of Kondo because 1) it would fundamentally change the process of Uozumi, and 2) it would obviate the use of the second solution of Uozumi" the examiner maintains that it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Uozumi of a two-step process for etching copper by replacing the solutions used in both steps with new

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solutions provided the new solutions yield better results, as is suggested in this case by Kondo. Kondo clearly suggests more stable etching characteristics relative to pH variations.

As to the applicant's argument citing "It would NOT have been obvious to modify the second solution of Uozumi as suggested by the Examiner because the modification would contradict the basic requirements of the second solution of Uozumi" the examiner suggests to replace both the first and second solutions because the new solutions yield better results, eliminating any contradiction with the teachings of Uozumi.

Rejection of claims 1-20 is maintained.

Conclusion

2. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

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the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mahmoud Dahimene whose telephone number is (571) 272-2410. The examiner can normally be reached on week days from 8:00 AM. to 5:00 PM..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Mahmoud Dahimene

MD

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PRIMARY EXAMINER
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